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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Several milestones have been reached in GaAs research. The first active GaAs device, a 1 (μm) channel width MESFET, has been made at Columbia. This device is a basic building block in Professor Fossum's GaAs CCD program. GaAs surface studies have also born fruit. UV light has been found to oxidize rapidly the surface of GaAs in an UHV environment containing traces of water vapor and O_2. The mechanism appears to be related to the generation of hot photocarriers.

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In addition, the use of diode lasers to measure the dynamics of molecules and atoms has again achieved major advances. The interaction between an electronically excited metal atom and a small polyatomic molecule has been investigated by probing for the first time the final quantum states of the polyatomic bath modes. These experiments are prototypical and can be expected to provide insight into the mechanisms responsible for energy transfer and chemical reactivity between metals and polyatomic molecules.

Finally, the first measurement of the absolute phase of the liquid surface nonlinear susceptibility was achieved using a novel application of second harmonic generation techniques. This information, which cannot be obtained directly from ordinary linear optical methods, made it possible to determine the absolute molecular orientation of molecules at air-liquid interfaces.

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FINAL REPORT

FOR THE

JOINT SERVICES ELECTRONICS PROGRAM

CONTRACT #DAAG29-85-K-0049

April 1, 1985 - March 31, 1988

COLUMBIA RADIATION LABORATORY

COLUMBIA UNIVERSITY in the City of New York

New York, New York 10027

May 1988

FINAL REPORT

for the

Columbia Radiation Laboratory

Joint Services Electronics Program

Contract # DAAG29-85-K-0049

April 1, 1985 - March 31, 1988

George W. Flynn
Co-Director, Columbia Radiation Laboratory

Richard M. Osgood, Jr.
Co-Director, Columbia Radiation Laboratory

May, 1988

A. DIRECTOR'S OVERVIEW

1. Management and Personnel: During this contract period, Columbia University has forcefully strengthened its program in solid-state electronics research. The Columbia Radiation Laboratory has clearly played the major role in catalyzing this growth. The most significant growth at Columbia University has been the addition of new faculty members with research programs in solid state physics: Professor Irving Herman (laser studies of solids), Professor Dave Auston (picosecond phenomena), and Professor Wen Wang (MBE growth). Of these three additions, Dr. Herman benefitted most directly from the use of Radiation Laboratory J.S.E.P. discretionary funds, which in this case provided an initial equipment guarantee. In addition, IBM supported his work with the CRL/IBM postdoctoral fellowship for two years. Professor Herman's research is in laser diagnostics of semiconductor processing and the spectroscopy (Raman and luminescence) of semiconductor superlattices. His research program is included in our new three year JSEP program.

Several other personnel changes were made at the end of this program. Professor Eisenthal's excellent work in ultrafast chemistry was transitioned into other federal agencies. Professor Yasutomo Uemura, a highly regarded physicist in synchrotron radiation studies of solids, was aided by the Columbia Radiation Laboratory administrative office in setting up his research program at Columbia. Finally, Professor Fossum's program in GaAs processing science was transferred out of JSEP and made into a larger research thrust, also in GaAs processing, in our new URI program.

Professors Wang, Auston and Herman, as well as several other CRL members, have had their programs strengthened by the recent awarding of an Office of Naval Research DoD-University Research Initiative Program grant in Interfacial and Thin Film Chemistry in Electron Device Fabrication to Columbia. During the first two years, the funds have been used to fund Columbia's first MBE machine, Herman's laser spectroscopy apparatus, a new UHV surface analysis system, and Auston's picosecond equipment.

Columbia has also received state financing for a new $50 million research building in the physical sciences and engineering on the Morningside Heights campus. A substantial portion of the CRL research effort will be housed in this building within a few years. One major portion of CRL research which will not be in the new physical science and engineering building, the program of Professor Flynn, has just moved into the new Chemistry addition which was completed in September 1987.

2. **Advances in Research Activities:** In addition to the above management changes, CRL has made major advances in its research activities as described below.

Several milestones have been reached in GaAs research. The first active GaAs device, a 1 μm channel width MESFET, has been made at Columbia. This device is a basic building block in Professor Fossum's GaAs CCD program. GaAs surface studies have also born fruit. UV light has been found to oxidize rapidly the surface of GaAs in an UHV environment containing traces of water vapor and 0_2. The mechanism appears to be related to the generation of hot photocarriers. This work was investigated by Dr. Chien Yu, while supported by the CRL/IBM Postdoctoral Fellowship expressly designated for CRL.

In addition, the use of diode lasers to measure the dynamics of molecules and atoms has again achieved major advances. The interaction between an electronically excited metal atom and a small polyatomic molecule has been investigated by probing for the first time the final quantum states of the polyatomic bath modes. These experiments are prototypical and can be expected to provide insight into the mechanisms responsible for energy transfer and chemical reactivity between metals and polyatomic molecules.

Finally, the first measurement of the absolute phase of the liquid surface nonlinear susceptibility was achieved using a novel application of second harmonic generation techniques. This information, which cannot be obtained directly from ordinary linear optical methods, allowed us to determine the absolute molecular orientation of molecules at air-liquid interfaces.

3. **Honors:** A variety of honors have been bestowed on CRL J.S.E.P. principal investigators during the past year. These include the following:

George Flynn, the Co-director of the Columbia Radiation Laboratory was named to the Thomas Alva Edison Professorship at Columbia. Professor Flynn has a long and distinguished record of research in laser studies of chemical dynamics. His work in intermolecular energy flow and his long tenure as CRL Director were particularly important in his being named to this distinguished Professorship.

Kenneth Eisenthal was designated a Fellow of the American Physical Society. This honor was based on his long series of seminal contributions to the application of picosecond techniques aimed at the understanding of molecular dynamics.

Eric Fossum has been designated an NSF Presidential Young Investigator. This designation resulted from his work in CCD's. Because of the scarcity of other university research in this area, he was able to obtain matching money for this special award quite readily.

Richard Osgood was honored with an IEEE traveling lectureship and designated Fellow of the IEEE. The title of Osgood's talk was "Laser Chemical Processing for Electronics," which he gave at approximately 50 IEEE societies across the country. Professor Osgood was also honored with a chaired professorship at Columbia; the Higgins Chair in Electrical Engineering. This honor was a result of his research in lasers and chemical physics, and his administrative activities at Columbia.

B. LISTING OF PRINCIPAL INVESTIGATORS

Kenneth Eisenthal
George Flynn
Eric Fossum
Sven Hartmann
Richard Osgood, Jr.
Mal Teich
Edward Yang

C. DEGREES AWARDED

Ph.D.

Brian B. Brady
Julian Chen
Lee Chen
Howard L. Evans
Janice Hicks
William Holber
Kamu Kasturi
Robert Kichinski
John Langan
Horace Ng
James O'Neill
J. S. Song
Garry B. Spector
Stanislav S. Todorov
Franklin Tong
M. Wordeman
Xu` Wu

M. S.

Dave McClure

M. A.

Hong Lu
Alonso Castro

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